UNIVERSITI PUTRA MALAYSIA

EFFICACY OF CALCIUM SUPPLEMENTATION AND WEIGHT-BEARING EXERCISE ON BONE MINERAL DENSITY IN POSTMENOPAUSAL CHINESE WOMEN

CHAN YOKE MUN

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By

CHAN YOKE MUN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Doctor of Philosophy

May 2003

This thesis is dedicated to
my parents and my husband, Sing Ziunn

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Doctor of Philosophy

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May 2003

Chairperson: **Associate Professor Dr. Zaitun Yassin, Ph.D.**

Faculty: **Medicine and Health Sciences**

The etiology of age-related bone loss is unclear but both habitually low calcium intake and lack of physical activity have been proposed as its determinants. The objective of this two-year randomized controlled trial was to evaluate the efficacy of increasing calcium intake and weight-bearing exercise on bone mineral density (BMD) in postmenopausal Chinese women who were not on hormone replacement therapy.

Bone mineral density at the total body, lumbar spine L_2-L_4, femoral neck, Ward's triangle, trochanter and total hip were measured using dual energy X-ray absorptionmetry (DEXA) at six month intervals. Information on sociodemographic background, lifestyle factors and reproductive history were assessed using a validated questionnaire. Calcium intake was evaluated by both the three-day food record and food frequency questionnaire at baseline, 12 and 24 months. Exercise habits were assessed with an exercise diary and Physical Activity Scale for the Elderly (PASE) questionnaire.

The baseline dietary data showed that dietary calcium intake was low among subjects with a mean intake of 444.0 ± 195.4 mg/day. Approximately 30% of the calcium intake was contributed by vegetables, beans and legumes while less than 15% was contributed from milk and dairy products.

The one-way within subjects ANOVA analysis indicated a significant time effect on bone loss for the control group at all skeletal sites. There were significant decreases in BMD at the total body (-0.77%), lumbar spine L_2-L_4 (-0.74%), femoral neck (-1.24%), Ward's triangle (-2.60%), trochanter (-3.17%) and total hip (-2.21%) in the control group at 24 months when compared to baseline. For the calcium group, there was decrease in BMD at Ward's triangle (-0.93%) but the decrease was not significant over time (95% confidence interval [CI]: -2.304 to 0.439; $p > 0.05$). There was virtually no significant bone loss in the calcium-exercise group at all the skeletal sites. There were significant increases in BMD at the femoral neck (+2.62%, $p < 0.05$), trochanter (+4.26%, $p < 0.05$) and total hip (+2.24%, $p < 0.05$). Inter-group comparisons on the changes in BMD over time were computed. Rate of bone loss was significantly higher in the control group as compared to the calcium or calcium-exercise group. There was a significant reduction in rate of bone loss in the calcium-exercise group as compared to calcium group at the femoral neck (+2.62% versus -0.90%), Ward's triangle (+2.17% versus -0.93%), trochanter (+4.26% versus -0.11%) and total hip (+2.24% versus -0.26%). This indicates an additional effect of weight-bearing exercise over calcium supplementation on the hip regions.

In conclusion, increasing calcium intake and weight-bearing exercise were both effective in reducing rate of bone loss in postmenopausal women. The additional effect of weight-bearing exercise on the hip regions may suggest a site-specific effect of weight-bearing exercise on BMD. A major fi

BMD and moderate exercise. This is important as it may be more feasible to encourage the public to engage in moderate exercises such as brisk walking rather than in strenuous exercise. These results support the implementation of a simple public health regimen to retard rate of bone loss by increasing calcium intake and encouraging moderate exercise.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KEBERKESANAN KALSIUM SUPPLEMENTASI DAN SENAMAN KE ATAS KETUMPATAN MINERAL TULANG DI KALANGAN WANITA CINA MENOPAUS

Oleh

CHAN YOKE MUN

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Pengerusi: **Profesor Madya Dr. Zaitun Yassin, Ph.D.**

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Walaupun etiologi kehilangan tulang berikutan penuaan tidak jelas, namun pengambilan kalsium yang rendah dan kekurangan aktiviti fizikal telah dikaitkan sebagai faktor penentunya. Objektif kajian kawalan rawak dua tahun ini adalah untuk menilai keberkesanan peningkatan pengambilan kalsium dan senaman ke atas ketumpatan mineral tulang (KMT) di kalangan wanita Cina posmenopaus yang tidak menerima terapi penggantian hormon.

Ketumpatan mineral tulang jumlah tubuh, lumbar L_2-L_4, pangkal pinggul, Ward, trokanter dan pinggul diukur dengan menggunakan kaedah 'dual energy X-ray absorptionmetry (DEXA)' setiap enam bulan. Maklumat latarbelakang sosiodemografi, faktor gaya hidup dan sejarah reproduktif telah ditentukan dengan penggunaan borang soal selidik yang telah divalidasi. Pengambilan kalsium telah dikaji dengan menggunakan kaedah rekod pengambilan makanan tiga hari dan borang kekerapan

pengambilan makanan yang dijalankan pada permulaan kajian, 12 bulan dan 24 bulan. Senaman telah dinilai dengan menggunakan diari senaman dan borang soal selidik Physical Activity Scale for the Elderly (PASE).

Data pengambilan makanan menunjukkan pengambilan kalsium adalah rendah, dengan purata pengambilan sebanyak 444.0 ± 195.4 mg/hari. Lebih kurang 30% pengambilan kalsium disumbangkan oleh sumber sayur-sayuran dan kekacang sementara susu dan hasil tenusu pula menyumbang kurang daripada 15% daripada jumlah pengambilan kalsium.

Ujian ANOVA satu-hala antara subjek menunjukkan terdapat kesan masa yang signifikan terhadap kehilangan tulang di semua bahagian tulang di kalangan kumpulan subjek kawalan. Sebanyak 0.77% (jumlah tubuh), 0.74% (lumbar), 1.24% (pangkal pinggul), 2.60% (Ward), 3.17% (Trokanter) dan 2.21% (pinggul) kehilangan tulang telah dicatatkan di kalangan kumpulan kawalan pada bulan ke-24 berbanding dengan permulaan kajian. Untuk kumpulan kalsium, walaupun kehilangan tulang sebanyak 0.93% telah dicatatkan pada bahagian Ward tetapi kehilangan itu adalah tidak signifikan (95% jangkal keyakinan: -2.304 kepada 0.439; $p > 0.05$). Untuk kumpulan kalsium-senaman, tidak ada sebarang kehilangan tulang yang dicatatkan di mana-mana bahagian tulang. Terdapat peningkatan KMT pada bahagian pangkal pinggul (+2.62%, $p < 0.05$), trokanter (+4.26%, $p < 0.05$) dan pinggul (+2.24%, $p < 0.05$). Perubahan KMT mengikut masa telah dibandingkan di antara kumpulan kajian. Kadar kehilangan tulang adalah lebih tinggi di kalangan kumpulan kawalan berbanding dengan kumpulan kalsium

ataupun kumpulan kalsium-senaman. Juga, kadar kehilangan tulang yang lebih rendah dicatatkan di kalangan kumpulan kalsium-senaman berbanding. kumpulan kalsium di bahagian pinggul (+2.24% berbanding -0.26%), pangkal pinggul (+2.62% berbanding 0.90%), ward (+2.17% berbanding -0.93%) dan trokanter (+4.26% berbanding -0.11%). Ini menunjukkan terdapat kesan tambahan akibat senaman di bahagian pinggul.

Kesimpulannya, peningkatan pengambilan kalsium dan senaman adalah berkesan untuk melambatkan kadar kehilangan tulang di kalangan wanita posmenopaus. Kesan tambahan akibat senaman di kawasan tulang pinggul mencadangkan kesan spesifik setempat senaman ke atas KMT. Perkaitan positif di antara KMT dan senaman sederhana merupakan satu keputusan yang bermakna kerana senaman sederhana seperti berjalan cepat adalah lebih mudah dilakukan berbanding dengan senaman yang lain. Data yang diperolehi menyokong implementasi regimen kesihatan awam untuk mengurangkan kadar kehilangan tulang melalui peningkatan pengambilan kalsium dan senaman sederhana.

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I certify that an Examination Committee met on 5th May 2003 to conduct the final examination of Chan Yoke Mun on her Doctor of Philosophy thesis entitled "Efficacy of Calcium Supplementation and Weight-bearing Exercise on Bone Mineral Density in Postmenopausal Chinese Women" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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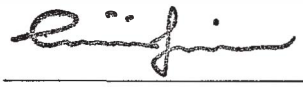

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

CHAN YOKE MUN

Date: 28 MAY 2003

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BMD	Bone Mineral Density
BMI	Body Mass Index
CI	Confidence Interval
DEXA	Dual Energy X-ray Absorptionmetry
ECF	Extracellular Fluid
NIH	National Institute of Health
PBM	Peak Bone Mass
PTH	Parathyroid Hormone
RDA	Recommended Dietary Allowance
RCT	Randomized Controlled Trial
WHO	World Health Organization
WHR	Waist Hip Ratio

CHAPTER 1

INTRODUCTION

1.1 Introduction

Osteoporosis was defined in 1993 as a systemic disease characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and increased fracture risk (Consensus Development Conference, 1993). Recently, this definition was modified as a skeletal disorder characterized by compromised bone strength predisposing to an increased risk of fracture (National Institutes of Health, 2000). Bone strength reflects the integration of two main features: bone density and bone quality. In the absence of accurate methods of measuring bone quality, the diagnosis of osteoporosis tends to be made on the basis of low bone density.

The rising incidence of osteoporosis and osteoporotic fractures is becoming a global public health problem. This is based on the recognition that it is a common disease in the developed countries and is likely to become so in the developing countries, where life span is rapidly increasing (Genant et al., 1999).

Primary osteoporosis affects mainly postmenopausal women. Women are at particular risk for fracture, and the data suggests that the incidence in women is twice that in men (Melton, 1988; Hoffenberg et al., 1989; Johnell et al., 1992). This has also been found to be true of Malaysia (Lau et al., 2001a). Above the age of 50 years, one in four women (Melton et al., 1992) and one in eight men (Melton et al., 1992; WHO, 1994) are

believed to have osteoporosis. The National Institutes of Health (NIH) of the United States (1998) pointed out that osteoporosis is about four times more common in women than in men. The higher occurrence of osteoporotic fractures in women is due to several factors. There are attainment of a lower bone mass at the time of maturity (bone mass is approximately 30% higher in men than in women (Consensus Conference, 1984)), women experiencing an accelerated loss of bone after the menopause, the greater likelihood of falls among elderly women (Winner et al., 1989) as well as to women's greater life expectancy (Genant et al., 1999). In total, women lose about 25-30% of the cortical bone and 35-50% of the trabecular bone over their lifetime (Riggs et al., 1981) while men lose about two-thirds of this rate.

1.2 Statement of Problem

Osteoporosis is a chronic and debilitating disease that can influence every facet of a person's life. It has been described as a primary factor contributing to deterioration of quality of life for the elderly (Birge, 1993). It affects more than 75 million people in the United States, Europe and Japan and causes more than 2.3 million fractures annually in the United States and Europe alone (Morii and Genant, 1998).

Postmenopausal bone loss is a major factor in the increasing prevalence of osteoporosis (Aloia et al., 1994). Osteoporosis is usually occult and asymptomatic until a fracture occurs. Thus, fractures are viewed as a complication of osteoporosis, and the relationship between osteoporosis and fractures is analogous to that between high blood pressure and